I should be glad if any worker who is able to send photographs will communicate with me as soon as possible so that I might arrange for the receiving and entry of the exhibit.

C. E. K. MEES

RESEARCH LABORATORY,
KODAK PARK,
ROCHESTER, N. Y.

SCIENTIFIC BOOKS

Definitions in Physics. By KARL EUGEN GUTHE, Ph.D., Professor of Physics in the University of Michigan and Dean of the Graduate Department. New York, The Macmillan Company. 1913. Pp. vii + 107.

A man's convictions are vastly more important than the logical processes by which he reaches them; and his convictions are represented in a large degree by the definitions which he adopts. It follows, therefore, that the appearance of a volume of definitions by a scholar of high standing in any particular field of thought is a matter of some moment. There is danger of taking physics too seriously; and nothing is easier than to employ definitions in such a way as to produce in the student-mind what Professor Franklin calls "a stress of dryness." But when the technical terms of his own science have been collected by a well-known specialist they become a matter of keen interest, and all the more so when that specialist is an experienced and successful teacher as is Professor Guthe.

Definitions grow as our ideas grow. They are not the fixtures of the Medes and Persians. Compare the modern definition of the crab with the classical one given in the French Academy's dictionary. Or consider how the resistance term in Ohm's law developed into impedance upon the introduction of alternating currents. Previous to the renaissance forces were defined only in a statical way; anything that would flatten out the muscles of the hand, bend a beam, disturb the configuration of a steelyard, or bring out any other strain requiring work was classified as a *force;* and conversely the term *force* was used at that time to include many ideas, such as *speed, impulse, energy* and *power,* which now lie quite without its limits. Shortly after the renaissance the concept of force was enlarged so as to take in the time-rate of change of momentum; later the generalized forces of Lagrange are included. Again the Peltier effect is defined quite differently from what it was before the Thomson effect was discovered.

A list of definitions is therefore a list of variable quantities and can hardly be regarded as more than a cross-section of the conventions agreed upon by the generation which uses them.

The book under review is one which can not fail to be of the utmost help to any student of general physics. The definitions are arranged under the classical five chapters of physics. Each quantitative concept is, as a rule, first defined in simple English and in terms already explained or assumed; next follows a mathematical expression which may be considered as a repetition of the first definition, and frequently, as an expression of natural law. The definitions are remarkable for their clearness, simplicity and brevity; if at any point indefiniteness suggests itself one feels that additional details have been omitted only to secure brevity. This feature is illustrated by the first paragraph in the book which defines *physics* in a manner which is elegant but so general as to leave doubt in the reader's mind as to whether physics and physical science are one and the same.

At the outset the author enunciates his conviction that "certain concepts used in physics are deductions and generalizations from individual experience and can not be strictly defined. Such are the concepts of *extension* (space, with its subdivisions of volume, area, length and direction), *time, force, warmth, cold,* etc." On the same page, a *physical quantity* is defined as "a definite concept capable of measurement."

Every one who thus finds *force* listed among the indefinables will surely understand that Professor Guthe here means to imply nothing more than that no complete and satisfactory definition has yet been given. For only a few

pages later we find that he himself offers the following definition:

"*Force* is the cause of a change or of a tendency to change in the state of rest of a body or of its deviation from uniform rectilinear motion. The idea of force is based upon the fundamental concept of the effort necessary to change the position of a body at rest or the uniform rectilinear motion of a body. It is assumed to be the cause of such a change, to be proportional to the acceleration produced, and to be in the direction of the added acceleration. It is a vector quantity. A force is measured by the equation $F = ma$, which may serve as a definition."

Waiving all considerations which might be urged against this definition on the ground that physics is not at all concerned with "causes," and laying aside all pedagogical considerations, your reviewer would like to ask, purely for information, this one question: Is there any single property, save only the space-variation of energy, which is characteristic of all the physical quantities which one finds labelled as "forces" by the leading physicists of the present time? Is there any single feature, or set of features, which can serve as a defining quality for force? No question is here raised about any general definition of force such as that which occupies ten columns of fine print in the great Oxford Dictionary. *The inquiry here made is much simpler. It pertains only to the forces which are employed every day in physics.* The one and serious objection against defining force in terms of energy or work is, of course, the fact that work and energy are universally defined in terms of force.

The crux of the situation would then appear to be the following: one is compelled either to employ the vicious circle just indicated or to discover some property other than space-variation of energy, which is common to all forces. It goes without saying, perhaps, that the space-variation here referred to is that employed by Lagrange in his definition of generalized force,[1] and is intended to include both angular and linear space. To make it perfectly clear that there is nothing hazy or indefinite about the query here raised it may be well to summarize the principal types of force which one meets in any standard discussion, such as that of Thomson and Tait, or Webster.

1. First of all there is the straightaway mass-acceleration in which the momentum of a particle is altered while its direction of motion remains constant, *e. g.*, a particle falling under gravity.

2. The force which produces a change in the direction of momentum of a particle, leaving the scalar value of its momentum constant, *e. g.*, contrifugal force, $mv\omega$.

3. The non-conservative force which is independent of the speed and is illustrated, within limits, by that of sliding friction. One may of course assign a part of the force of friction to the mass-acceleration of the small abraded particles.

4. The non-conservative force which varies directly as the speed, and possesses a dissipation function, illustrated by certain viscous resistances. Here again one may assign acceleration, hence speed and heat, to the small invisible particles.

5. The force which produces a change in the shape or size of an elastic body or in the configuration of a gravitational, magnetic or electric system.

The reader will find a more elegant analysis of the typical mechanical forces in Webster's "Dynamics," p. 123; but the above list suffices to show the diversity in which some common factor is sought. If we admit that a mass-acceleration is characteristic of the first four types listed above, can the all-powerful electron theory bring the fifth type also into this category? Or is there some better way around this *impasse?* Or must we concur with Professor Guthe in his opinion that force can not be defined? To say that it is sometimes definable and sometimes not is about as satisfactory as that ancient testimonial of good character which asserted that "the man is honest; at least he is honest nine times out of ten." Even those who believe there is something profound and mysterious about the concept of force, just as there is something

[1] *Mec. Anal.*, I., p. 334.

away beyond our ken in the structure of matter, say of copper, will confess that the chemist can point to a certain set of properties which are necessary and sufficient to delimit copper from every other known substance. The question here raised is similar, namely, Can forces be grouped into a class by themselves? And, if so, what are the marks, or the one mark, by which this class is set off from the other physical quantities? Dr. Dadourian, in his "Analytical Mechanics," p. 15, has perhaps given an answer to this question: but if so, only by introducing a term—*action*—which the intelligent reader will consider an undefined synonym of *force,* equally complex and equally indefinite.[2] Every one agrees that a force is represented, in a general way, by a *push* or *pull;* but the question here raised is this: How is a *push* to be defined in a quantitative and consistent manner?

Returning now from this digression suggested by Professor Guthe's treatment of mechanics, the definitions in *Sound* and *Heat* are brief and excellent. Those in Magnetism and Electricity are introduced with the interesting remark that "the existence of ether in space is accepted as a means of interpreting phenomena that can not be explained by the properties of ordinary matter." The definitions which follow are especially fine and are certain to furnish new and helpful viewpoints to any serious student; the same is true of the section devoted to optics. Where differences of opinion might arise—and they are numerous—one feels always that the text, as it stands, clearly sets forth the essential facts of the case.

Henry Crew

Introduction to the Study of Igneous Rocks. By George I. Finlay, Ph.D. New York and London. McGraw-Hill Book Company, Inc. 1913. Pp. vii + 228. Price $2.00 net.

This little book is said by its author to be intended as an introduction to the exhaustive treatises on the subject of igneous rocks, and consists of a brief statement of the qualitative classification of igneous rocks; a description of the method of determining such rocks in hand specimens, and a short chapter on the optical properties of minerals and the methods by which they are determined. This is followed by chapters on identification of the essential and accessory minerals of igneous rocks; and by chapters on the "igneous type rocks" and of varietal rocks related to the type rocks; a brief synopsis of a method of describing rocks; and an outline of the quantitative classification of igneous rocks, with numerous examples of the method of calculation of the norm, with numerical tables to facilitate the calculation. There are also tabulated statements of the physical characteristics of the chief rock minerals.

The book is well gotten up and is to be commended for its author's appreciation of the value of quantitative methods of determination and description, and for his simple and direct manner of describing the ordinary method of procedure in the customary identification of rocks in hand specimens, and of minerals under the microscope.

It is a mistake, however, to call the book an introduction to the more serious study of igneous rocks as set forth in larger treatises on the subject. It would seem to have been prepared for a class of students who did not intend to study the subject thoroughly, a very large and legitimate class who desire only a slight knowledge of the subject. For the work labors under the disadvantage of an attempt to simplify a highly complex subject, and to express in a few words ideas and definitions which require fuller statements and amplification in order to be correct. The attempt has led the author into some errors that he might have avoided. It has emphasized the idea of rock types, which will lead students to expect what they will not find in nature, and it has given false ideas as to the composition of rocks having the commonest names. The author himself remarks that the concise statement made in the table of igneous rocks on page 98 may readily be misinterpreted by the beginner. Why then make it? It certainly conveys the impression that andesites are characterized by mica and amphibole, and that

[2] See Rettger, Science, January 23, 1914, p. 140.